(12) UK Patent Application (19) GB (11) 2 279 778 (13) A

(43) Date of A Publication 11.01.1995

(21) Application No 9410084.9

(22) Date of Filing 19.05.1994

(30) Priority Data
(31) 938571 (32) 19.05.1993 (33) KR
9314203 26.07.1993

(51) INT CL^6
G10K 11/178, A47L 9/00

(52) UK CL (Edition N)
G3R RA36 RA37 RA382 RBS RB55
A4F FD12 FEF12 FFB203 FFE FG29 FHC13
H4J JGA
U1S S1233

(56) Documents Cited
GB 2257601 A GB 2257327 A GB 2242098 A
GB 2222501 A GB 2132053 A GB 2130651 A

(58) Field of Search
UK CL (Edition M) G3R RBS RBU, H4J JGA
INT CL^5 G05D 19/02, G10K 11/16
Online databases: WPI

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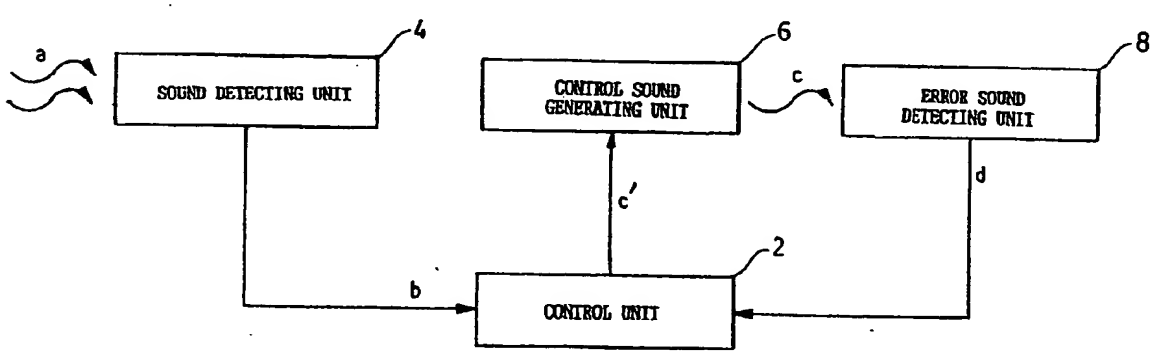
(54) Reducing vacuum cleaner noise

(57) In a vacuum cleaner noise suppression system, a sound generator 6 is controlled so as to produce a sound having equal intensity as the noise generated by the vacuum cleaner but in antiphase thereto so as to cancel the noise produced by the cleaner. The sound generator is controlled to produce an output to attenuate the noise a detected by a first microphone 4 but also compensates for any residual noise c detected by a second microphone 8.

The noise detecting microphone 4 can be mounted on the motor housing and the residual noise microphone mounted remote from the motor eg in the air filter.

FIG.1



GB 2 279 778 A

FIG.1

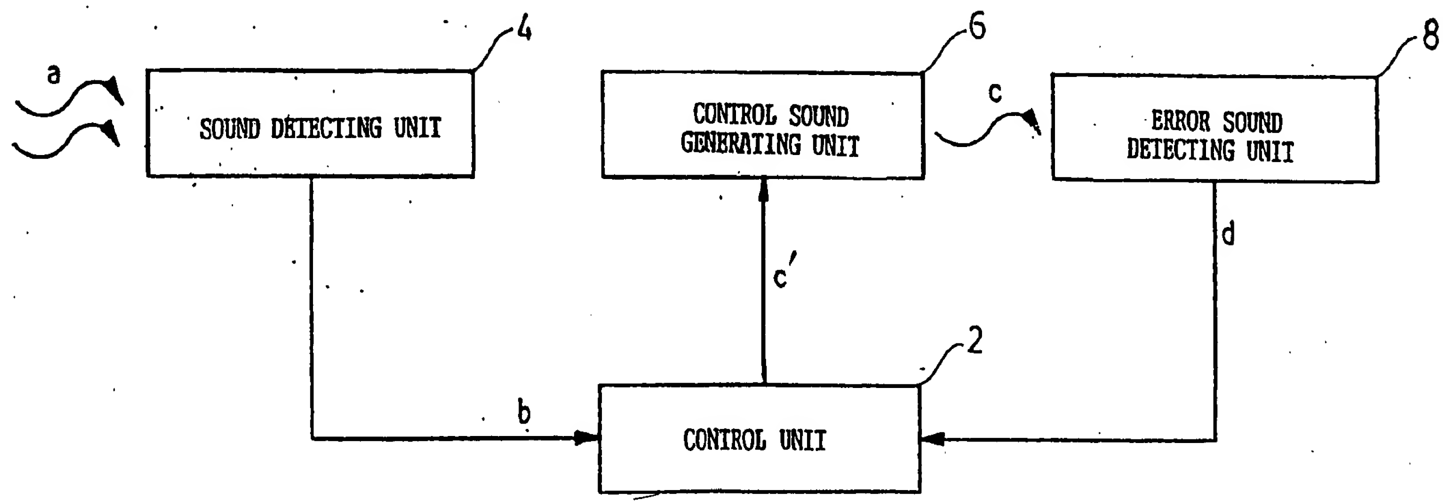
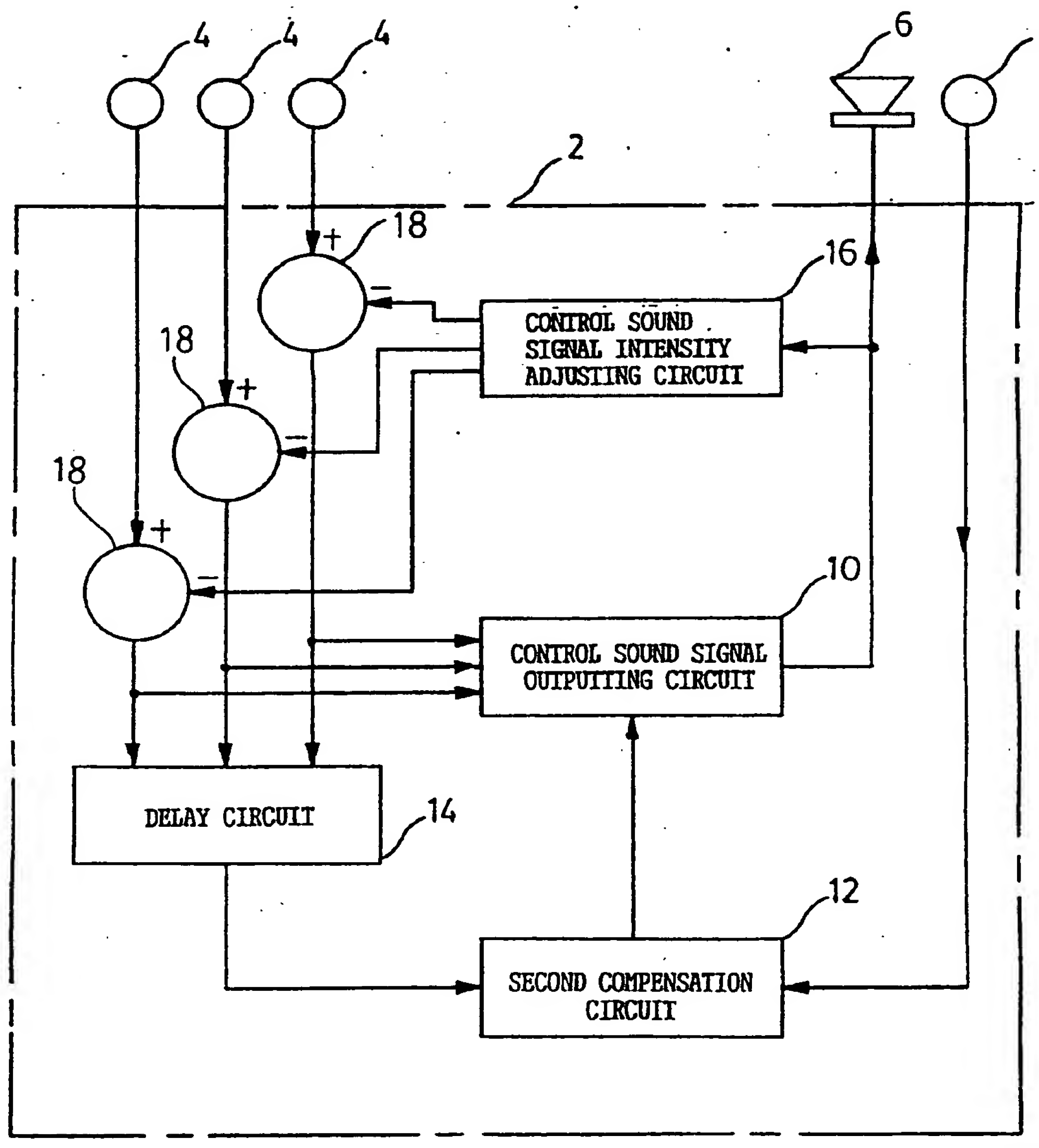

a
SOUND DETECTING UNIT
4
CONTROL SOUND GENERATING UNIT
6
c
ERROR SOUND DETECTING UNIT
8
d
c′
2
b
CONTROL UNIT

FIG.2


4
4
4
6
8
2
18
18
18
16
10
14
12
+
−
CONTROL SOUND SIGNAL INTENSITY ADJUSTING CIRCUIT
CONTROL SOUND SIGNAL OUTPUTTING CIRCUIT
DELAY CIRCUIT
SECOND COMPENSATION CIRCUIT

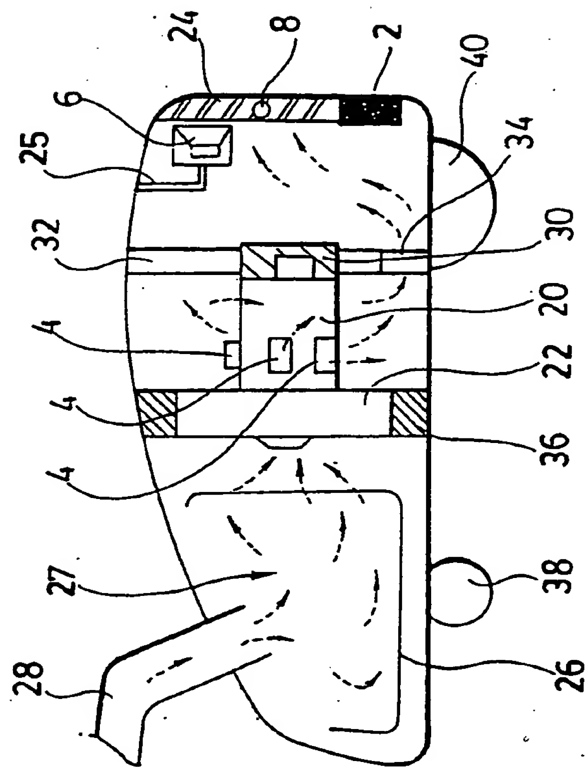


FIG.3

FIG. 4A

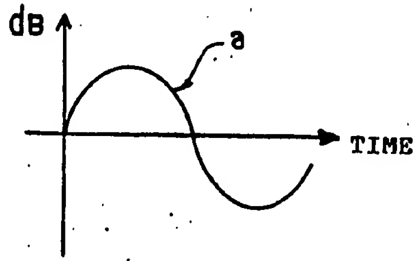


FIG. 4B

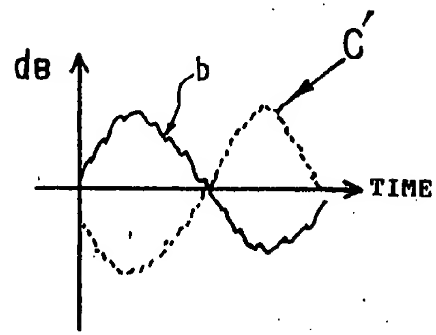


FIG. 4C

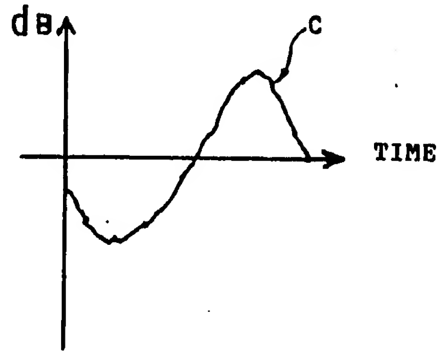
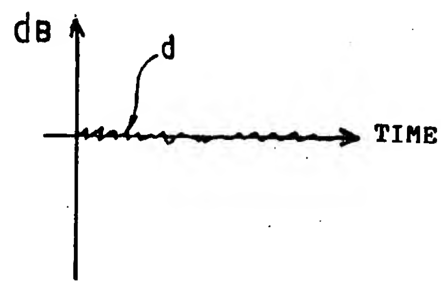


FIG. 4D



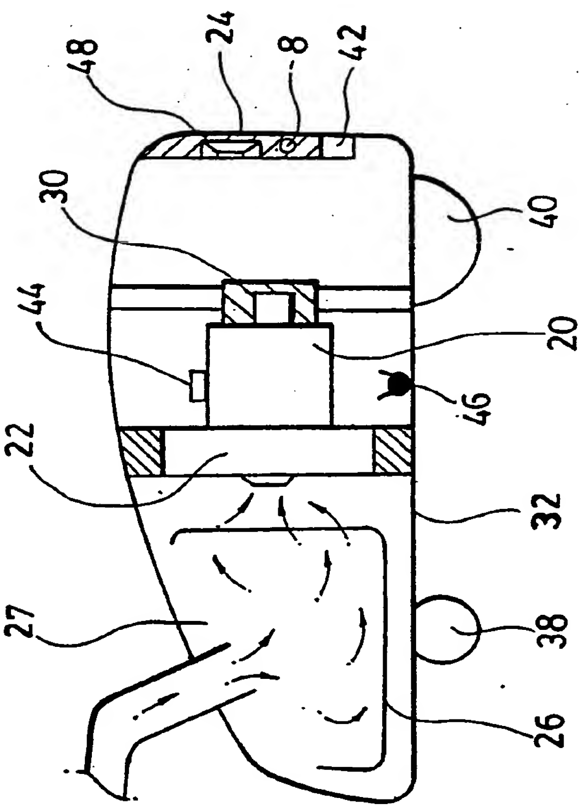
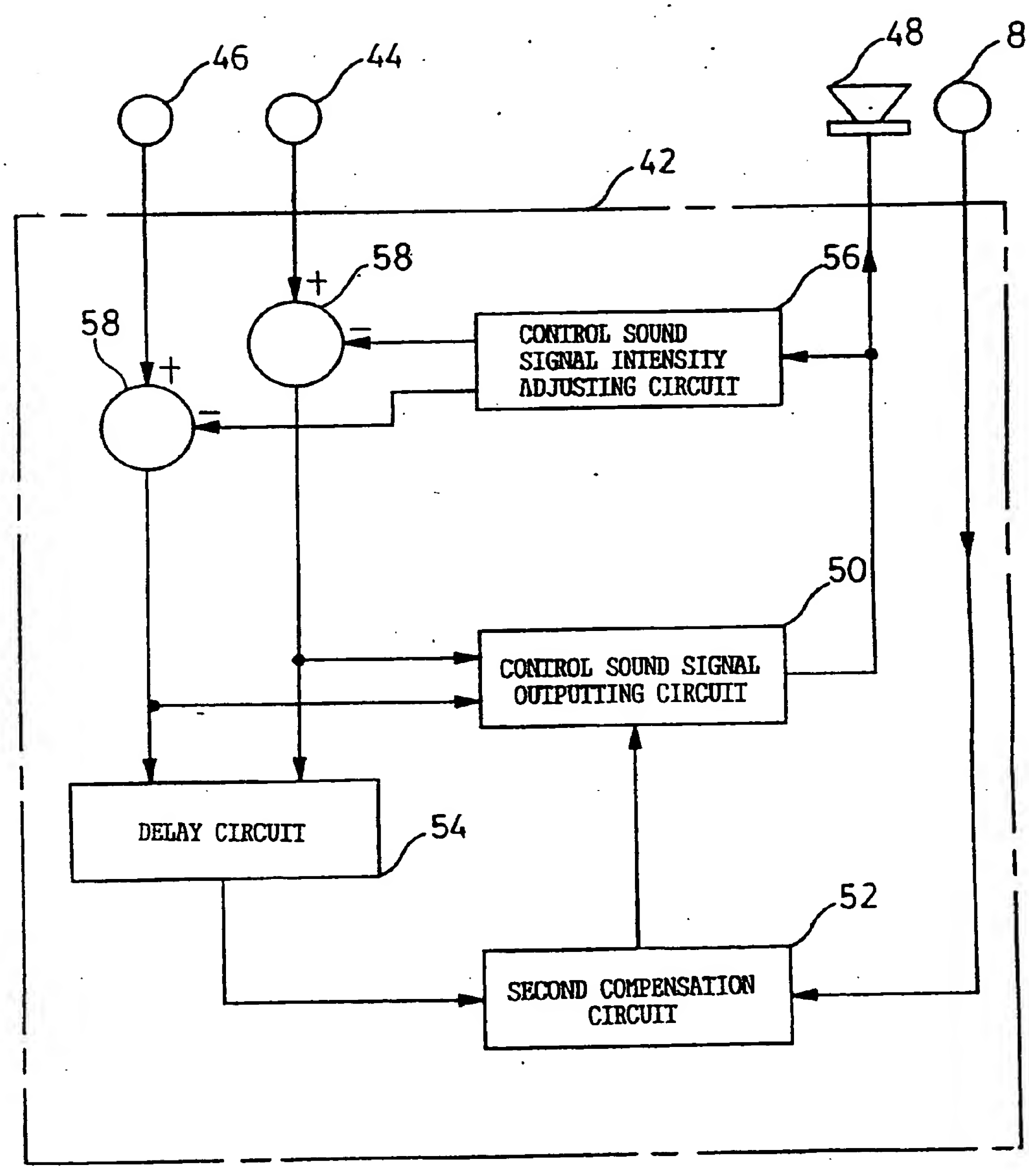


FIG .5A

FIG.5B


46
44
48
8
42
58
58
56
CONTROL SOUND SIGNAL INTENSITY ADJUSTING CIRCUIT
50
CONTROL SOUND SIGNAL OUTPUTTING CIRCUIT
DELAY CIRCUIT
54
52
SECOND COMPENSATION CIRCUIT

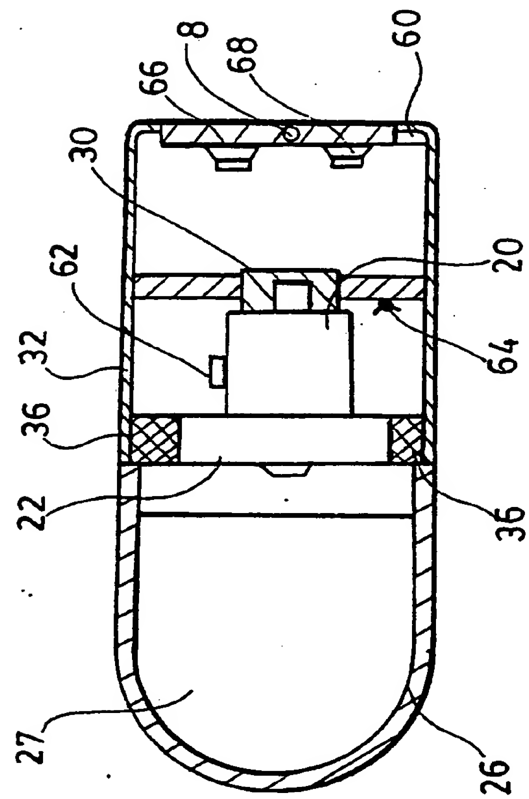


FIG. 6A

FIG. 6B

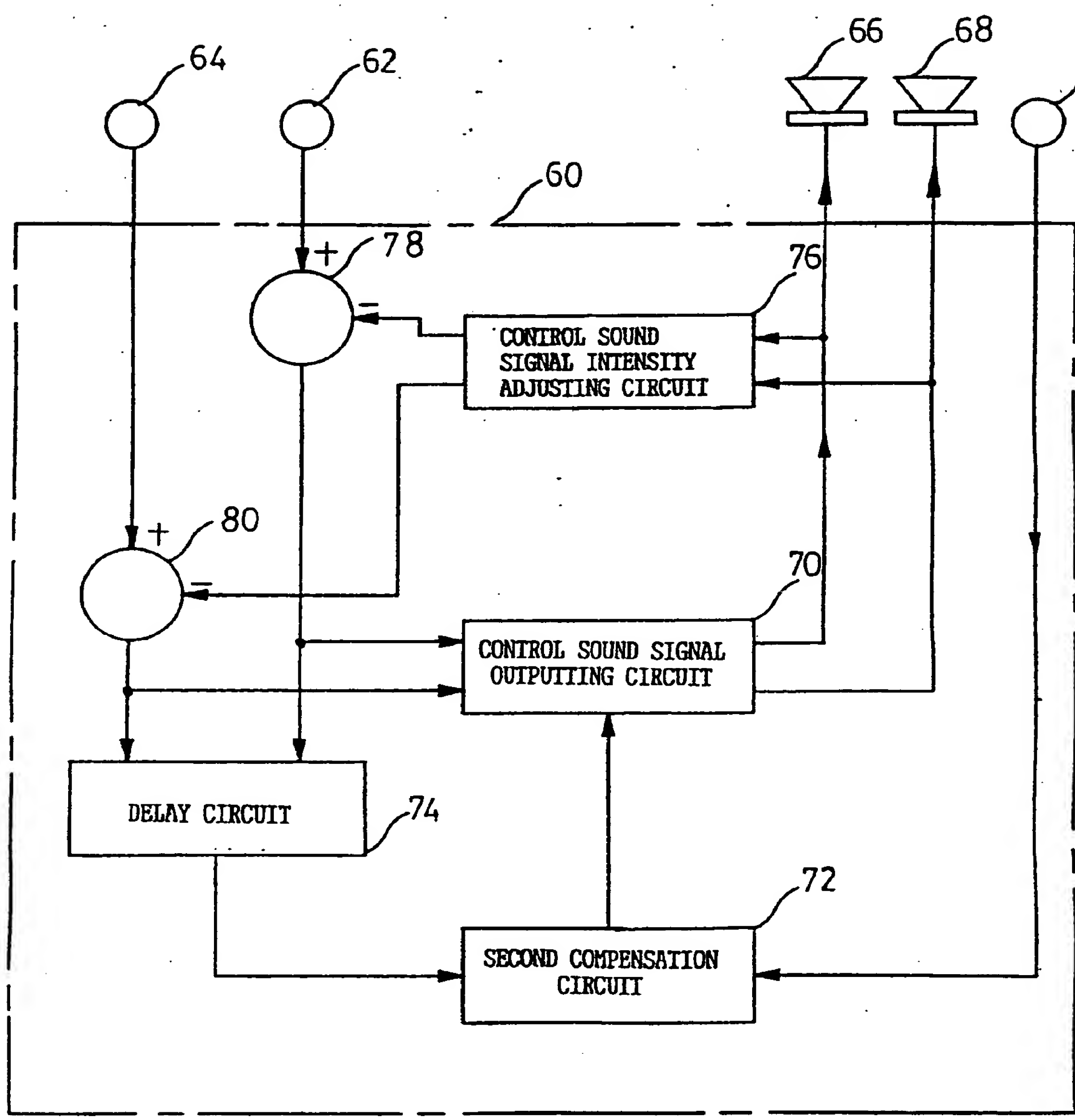

64
62
66
68
8
60
78
76
CONTROL SOUND SIGNAL INTENSITY ADJUSTING CIRCUIT
80
70
CONTROL SOUND SIGNAL OUTPUTTING CIRCUIT
DELAY CIRCUIT
74
72
SECOND COMPENSATION CIRCUIT

FIG.7A

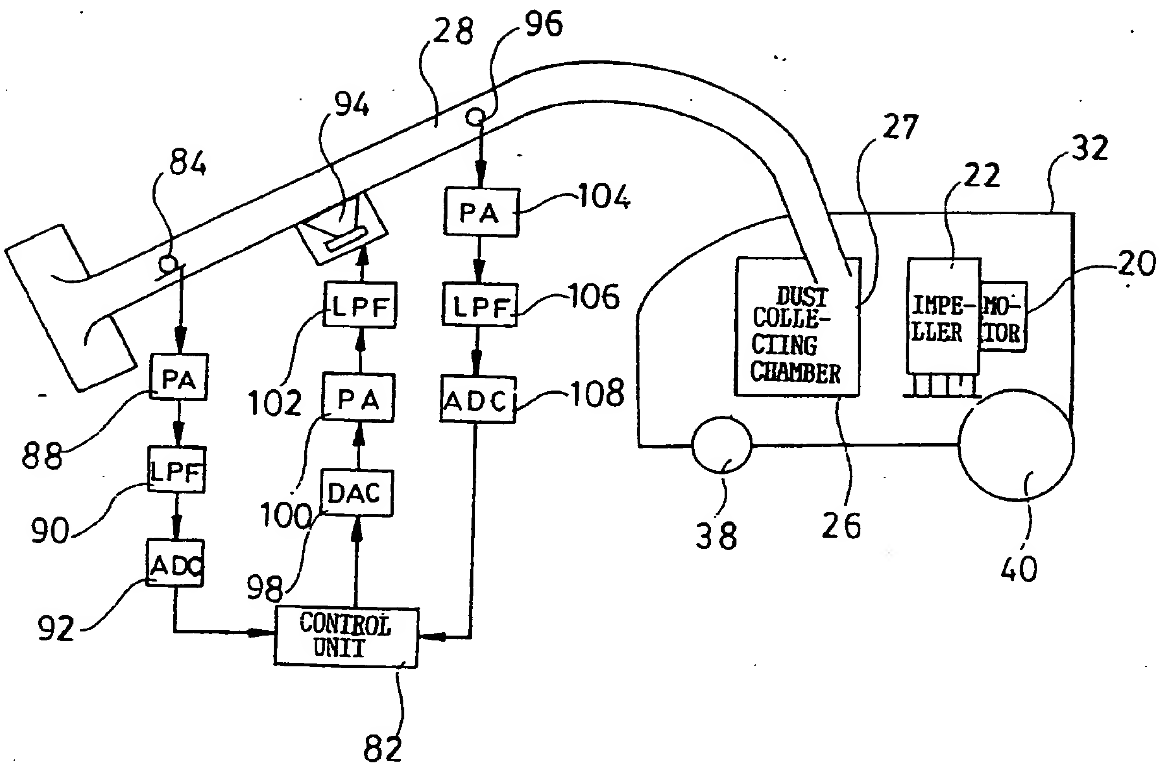

28
96
94
84
PA
104
LPF
LPF
106
102
PA
ADC
108
PA
88
LPF
DAC
100
90
ADC
98
92
CONTROL UNIT
82
27
22
32
20
DUST COLLE-CTING CHAMBER
IMPE-LLER
MO-TOR
38
26
40

FIG 7B

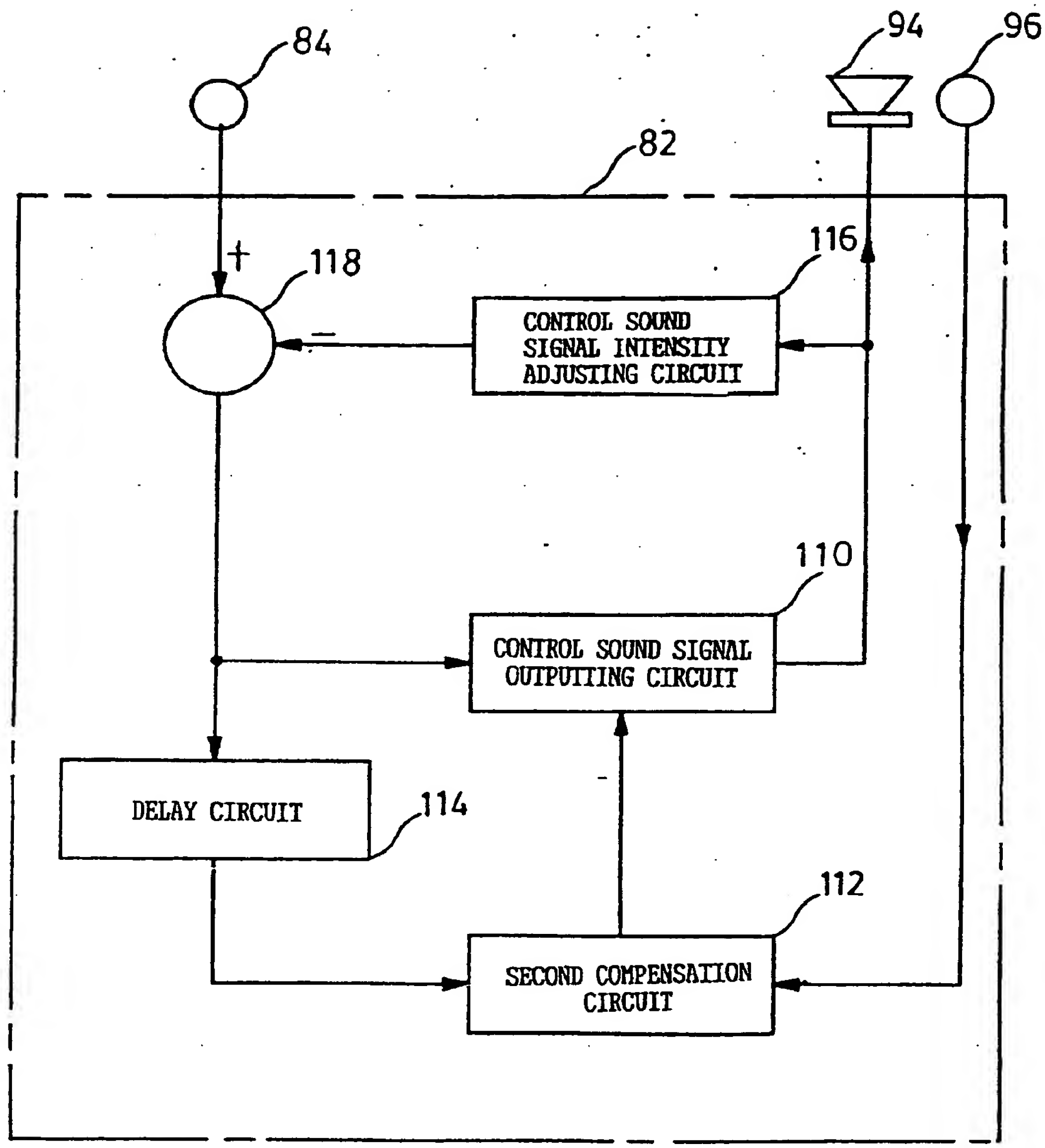

84
94
96
82
116
118
+
−
CONTROL SOUND SIGNAL INTENSITY ADJUSTING CIRCUIT
110
CONTROL SOUND SIGNAL OUTPUTTING CIRCUIT
DELAY CIRCUIT
114
112
SECOND COMPENSATION CIRCUIT

FIG. 8

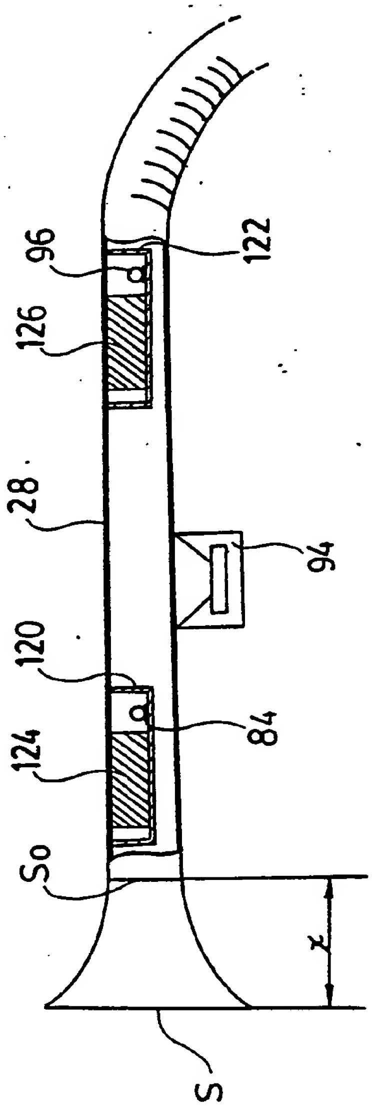
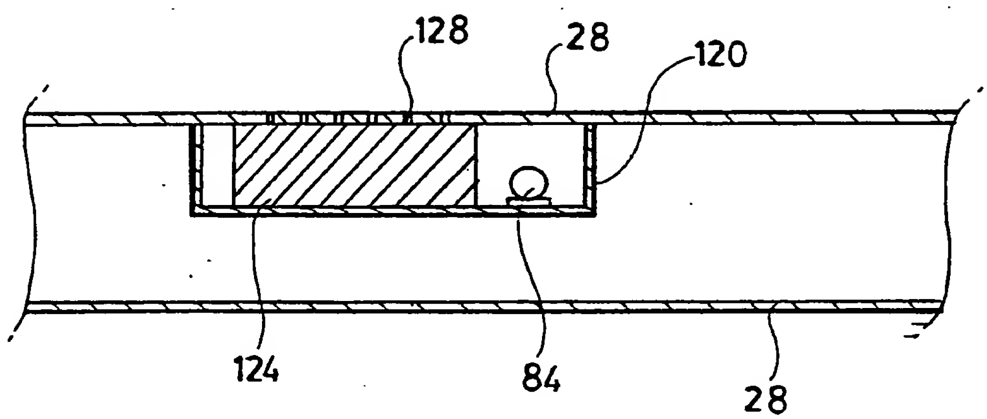


FIG. 9



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NOISE CONTROL APPARATUS FOR VACUUM CLEANER

DESCRIPTION

The present invention relates to an active noise control apparatus for a vacuum cleaner.

Generally, noise generated in vacuum cleaners is present in a wide frequency band. For removing such a noise, various proposals have been made. For example, there has been proposed the installation of a sound-absorbing member, surrounding both the impeller and the motor disposed in a vacuum cleaner, as disclosed in Japanese Patent Laid-open Publication Sho 62-32903, and the provision of an elongated passage (air passage) in a vacuum cleaner.

Although these noise control methods are good at removing noise having a frequency of 500Hz or above, they encounter problems in removing lower frequency noise. For removing such lower frequency noise, a sound-absorbing member having increased thickness must be used. Due to such an increase in thickness, the sound-absorbing member may be difficult to install in the interior of a vacuum cleaner.

It is an aim of the present invention to overcome a disadvantage in the prior art.

According to the present invention, there is provided a noise control apparatus for a vacuum cleaner comprising: control means; noise detecting means for detecting a noise generated ftom a noise source, generating a noise level signal on the basis of the noise detection, and sending the noise level signal to the control means; control sound generating means for generating a control sound adapted to attenuate the noise from the noise source under a control of the control means; and error sound detecting means for detecting an error sound indicative of the result of the noise attenuation by the control sound from the control sound generating means, generating an error sound signal on the basis Of the error sound detection, and sending the error sound signal to the control means.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawing in which:

Figure 1 is a block diagram of a noise control apparatus a vacuum cleaner in accordance with a first embodiment of the present invention;

Figure 2 is a block diagram of a control unit shown in Figure 1;

Figure 3 is a sectional view of the vacuum cleaner shown in Figure 1, showing the arrangement of the noise control apparatus in the vacuum cleaner;

Figures 4A to 4D' are diagrams respectively illustrating waveforms of various parts of the noise control apparatus. Shown in Figure 1;

Figure 5A is a sectional view of a noise control apparatus for a vacuum cleaner in accordance with a second embodiment of the present invention;

Figure 5B is a block diagram of a control unit shown in Figure 5A;

Figure 6A is a sectional view of a noise control apparatus for a vacuum cleaner in accordance with a third embodiment of the present invention;

Figure 6B is a block diagram of a control unit shown in Figure 6A;

Figure 7A is a schematic view of a noise control apparatus for a vacuum cleaner in accordance with a fourth embodiment of the present invention;

Figure 7B is a block diagram of a control unit shown in Figure 7A;

Figure 8 is a sectional view of a suction pipe equipped in the vacuum cleaner shown in Figure 7A; and

Figure 9 is an enlarged view of a part of the suction shown in Figure 8.

As shown in Figure 1, the noise control apparatus comprises a control unit 2 and a noise detecting unit 4 for detecting noise generated by a noise source, which will be described

hereinafter. The noise detecting unit 4 generates a noise level signal on the basis of the detection and sends it to the control unit 2. A control sound generating unit 6 is also provided which serves to receive a control signal from the control unit 2 and thereby generates a control sound for attenuating the noise generated by the noise source. The noise control apparatus further comprises an error sound detecting unit 8 for detecting an error sound indicative of the result of the attenuation of the noise from the noise source by the control sound from the control sound generating unit 6. The error sound detecting unit 8 generates an error sound signal on the basis of the detection and sends it to the control unit 2.

The control unit 2 is a microprocessor for controlling the overall operations of the noise control apparatus. As shown in Figure 2, the control unit 2 comprises a control sound signal outputting circuit 10 adapted to receive the noise signal from the noise detecting unit 4 and generate a control sound signal having the same amplitude and intensity as those of the noise signal and the opposite phase to that of the noise signal. The control sound signal from the control sound signal outputting circuit 10 is transmitted to the control sound generating unit 6. The control unit 2 further comprises a pair of compensation circuits, the first one of which is denoted by the reference numeral 18

and the second one of which is denoted by the reference numeral 12. The second compensation circuit 12 serves to generate a compensation signal for minimizing the intensity of the error sound. For generating such a compensation signal, the second compensation circuit 12 performs an operation for the compensation signal, based on the error sound signal generated from the error sound detecting unit 8 and the noise-signal detected by the noise detecting unit 4. The compensation signal from the second compensation circuit 12 is sent to the control sound signal outputting circuit 10. A delay circuit 14 is coupled between noise detecting unit 4 and the second compensation circuit 12. The delay circuit 14 is adapted to delay the noise signal outputted from the noise detecting unit 4 for a predetermined time so as to synchronize the noise generated from the noise source and the control sound generated from the control sound generating unit 6 at the stage of the error sound detecting unit 8. The delayed noise signal from the delay circuit 14 is sent to the second compensation circuit 12. The control unit 2 further comprises a control sound signal intensity adjusting circuit 16 adapted to receive the control sound signal from the control sound signal outputting circuit 10 and adjust the intensity of the received signal. The first compensation circuit 18 serves to transmit only the noise generated from the noise source to the control sound signal outputting circuit 10 and

the delay circuit 14. To this end, the first compensation circuit 18 subtracts the control sound signal generated from the control sound signal outputting circuit 10 and adjusted in intensity by the intensity adjusting circuit 16 from the noise signal detected by the noise detecting unit 4. The noise signal compensated on the basis of the subtraction is sent to both the control sound signal outputting circuit 10 and the delay circuit 14.

The second compensation circuit 12 is constructed to perform the operation for generating the compensation signal in accordance with the least mean square algorithm.

The noise detecting unit 4 is a microphone attached to the outer surface of a housing of a dust-sucking motor 20 and adapted to detect noise generated from the dust-sucking motor 20 and an impeller 22 driven by the dust-sucking motor 20, as shown in Figure 3.

In the first embodiment of the present invention, the motor 20 and the impeller 22 constitute together the noise source.

On the other hand, the control sound generating unit is a speaker disposed in the vicinity of an air filter 24 at the rear portion of the vacuum cleaner and attached to a body 32

of the vacuum cleaner by means of a fixture 25 such that it faces outwardly of the vacuum cleaner. The speaker serves to attenuate the noise generated from the motor 20 and the impeller 22 so as to prevent the noise from being transmitted outwardly of the vacuum cleaner.

The error sound detecting unit 8 is a microphone disposed in the interior of the air filter 24 and adapted to detect error sound indicative of the result of the attenuation of the noise generated from the dust-sucking motor 20 and the impeller 22 by the control sound generated from the control sound generating unit 6.

As shown in Figure 3, a dust collecting pack 26 is separably disposed in one side of the motor 20 and the impeller 22. The dust collecting pack 26 defines therein a dust collecting chamber 27, to which a suction pipe 28 is connected.

A damper 30 as a second damper is disposed at the rear portion of motor 20 coupled to the cleaner body 32 so as to attenuate vibration generated from the motor 20 and transmitted to the cleaner body 32. Beneath the damper 30 fluid passage 34 is defined in the interior of the cleaner body 32. The fluid passage 34 serves to guide an air sucked into the dust collecting chamber 27 through the suction pipe

28 to the air filter 24 via the impeller 22, as indicated by phantom arrow in Figure 3.

Another damper 36 as a first damper is disposed at the outer surface of a bracket for fixedly mounting the impeller 22 so as to attenuate vibration generated from the impeller 22.

The control unit 2 is disposed beneath the air filter 24. Wheels 38 and 40 are rotatably mounted to the bottom portion of the cleaner body 32 so as to enable travel of the cleaner body 32.

Operation of the noise control apparatus for the vacuum cleaner in accordance with the first embodiment of the present invention will now be described.

When a user plugs in the vacuum cleaner, voltage of AC 220 volts is applied to DC voltage supply source means (not shown) equipped in the cleaner body 32. As a result, voltage of DC 5 volts is generated from the DC voltage supply source means and then applied to the control unit 2. The DC voltage supply source means also generates voltage of DC 12 volts which is, in turn, applied to the noise detecting unit 4, the error sound detecting unit 8 and the control sound generating unit 6. Accordingly, the control unit 2, the noise detecting unit 4, the control sound

generating unit 6 and the error sound detecting unit 8 can operate.

When the user switches on a drive switch not shown for performing a cleaning under the above condition, the motor 20 is driven, thereby causing the impeller 22 to rotate. As the motor 20 and the impeller 22 rotate, noise a having characteristic shown in Figure 4A is generated from both the motor 20 and the impeller 22. The noise a is then detected by the noise detecting unit 4 which, in turn, generates a noise signal b having a characteristic indicated by a solid line in Figure 4B. The noise signal b from the noise detecting unit 4 is sent to the first compensation circuit 18 of the control unit 2.

At this time, the control sound signal intensity adjusting circuit 16 does not apply any control sound signal to the first compensation circuit 18 yet. As a result, the first compensation circuit 18 sends the noise signal b, as it is, to both the control sound signal outputting circuit 10 and the delay circuit 14.

Based on the received noise signal b, the control sound signal outputting circuit 10 generates a control sound signal c' having the same amplitude and intensity as those of the noise signal b and the opposite phase to that of the

noise signal b, as indicated by a phantom line in Figure 4B. The control sound signal c from the control sound signal outputting circuit 10 is then sent to both the control sound generating unit 6 and the intensity adjusting circuit 16.

Based on the control sound signal c′, the control sound generating unit 6 generates a control sound c having the intensity and frequency as those of the noise signal b and the opposite phase to that of the noise a generated from both the motor 20 and the impeller 22, as shown in Figure 4C.

The noise generated from the motor 20 and the impeller 22 is then attenuated by the control sound generated from the control sound generating unit 6. As a result, only an error sound d having a characteristic shown in Figure 4D is left in the cleaner body 32.

This error sound d is detected by the error sound detecting unit 8 which, in turn, generates an error sound signal and sends it to the second compensation circuit 12 of the control unit 2.

On the other hand, upon receiving the noise signal b indicated by the solid line in FIG. 4B from the

first compensation circuit 18, the delay circuit 14 delays the noise signal b for a predetermined time so as to synchronize the noise transmitted from the motor 20 and the impeller 22 with the control sound outputted from the control sound generating unit 6 at the stage of the error sound detecting unit 8. After the delay, the delay circuit 14 sends the noise signal to the second compensation circuit 12.

Then, the second compensation circuit 12 performs an operation for a compensation signal for minimizing the intensity of the error signal in accordance with the least mean square algorithm, based on the error sound signal generated from the error sound detecting unit 8 and the-noise 20 signal detected by the noise detecting unit 4. The compensation signal from the second compensation circuit 12 is then applied to the control sound signal outputting circuit 10.

Thereafter, the control sound signal outputting circuit 10 generates a control sound signal corrected on the basis of the compensation signal and applies it to both the control sound generating unit 6 and the control sound signal intensity adjusting circuit 16.

Based on the corrected control sound signal, the control

sound generating unit 6 generates a corrected control sound which is, in turn, applied to the interior of cleaner body 32.

As a result, the error sound left in the cleaner body 32 is removed by the corrected control sound generated from the control sound generating unit 6. Thus, the circumstance of the vacuum cleaner can be kept under a comfortable condition.

On the other hand, upon receiving the control sound signal from the control sound signal outputting circuit 10, the intensity adjusting circuit 16 adjusts the control sound signal in intensity. The intensity-adjusted control sound signal from the intensity adjusting circuit 16 is then sent to the first compensation circuit 18.

The first compensation circuit 18 subtracts the control sound signal generated from the control sound signal outputting circuit 10 and adjusted in intensity by the intensity adjusting circuit 16 from the noise signal detected by the noise detecting unit 4. By this subtraction, only the noise signal having the intensity equivalent to the noise generated from the motor 20 and impeller 22 is sent to the control sound signal outputting circuit 10 and the delay circuit 14.

As the user moves the cleaner body 32 along a floor to be cleaned, for the cleaning, dust on the floor is sucked together with air into the dust collecting chamber 27 via the suction pipe 28. The air is filtered in the dust collecting chamber 27 so that the dust can be collected in the dust collecting chamber 27. The air free of dust passes through the impeller 22, the fluid passage 34 and the air filter 24, in this order, to be vented out of the cleaner body 32. During this cleaning, the above-mentioned noise control operation is continued. Accordingly, the circumstance of the vacuum cleaner can be always kept under a comfortable condition.

Referring to Figures 5A and 5B, there is illustrated a noise control apparatus for a vacuum cleaner in accordance with a second embodiment of the present invention.

In Figures 5A and 5B, elements corresponding to those in Figures 1 to 4 illustrating the first embodiment of the present invention are denoted by the same reference numerals and, thus, their description will be omitted.

In accordance with this embodiment, the noise detecting unit adapted to detect noise generated from the motor 20 and the impeller 22 and generate a noise level signal on the basis of the detection comprises a first noise defecting unit 44

and second noise detecting unit 46. The first noise detecting unit 44 is attached to the outer surface of the housing of motor 20 whereas the second noise detecting unit 46 is attached to the bottom surface of cleaner body 32 such that it is spaced apart from both the motor 20 and the impeller 22.

In similar to the noise control apparatus of the first embodiment, the noise control apparatus of the second embodiment includes a control unit 42 which is a microprocessor for controlling the overall operations of the noise control apparatus. As shown in Figure 5B, the control unit 42 comprises a control sound signal outputting circuit 50 adapted to receive noise signals from the first and second noise detecting units 44 and 46, derive an average of the receive noise signals, generate a control sound signal having the same amplitude and intensity as those of the average noise signal and the opposite phase to that of the average noise signal. The control sound signal from the control sound signal outputting circuit 50 is transmitted to a control sound generating unit 48 which is identical to the control generating unit 6 of the first embodiment. The control unit 42 further comprises a pair of compensation circuits, the first one of which is denoted by the reference numeral 58 and the second one of which is denoted by the reference numeral 52. The second compensation

circuit 52 serves to generate a compensation signal for minimizing the intensity of the error sound. For generating such a compensation signal, the second compensation circuit 52 performs an operation for the compensation signal, based on the error sound signal generated from the error sound detecting unit 8 and the noise signals respectively detected by the first and second noise detecting unit 44 and 46. The compensation signal from the second compensation circuit 52 is sent to the control sound signal outputting circuit 50. A delay circuit 54 is also provided for delaying the noise signals respectively outputted from first and second noise detecting unit 44 and 46 for a predetermined time so as to synchronize the noise generated from the noise source and the control sound generated from the control sound generating unit 48 at the stage of the error detecting unit 8. The delayed noise signal from the delay circuit 54 is sent to the second compensation circuit 52. The control unit 42 further comprises a control sound signal intensity adjusting circuit 56 adapted to receive the control sound signal from the control sound signal outputting circuit 50 and adjust the intensity of the received signal. The first compensation circuit 58 serves to transmit only the noise generated from the noise generated from the noise source to the control sound signal outputting circuit 50 and the delay circuit 54. To this end, the first compensation circuit 58 subtracts the control sound

signal generated from the control sound signal outputting circuit 50 and adjusted in intensity by the intensity adjusting circuit 56 from each of the noise signals detected by the first and second noise detecting unit 44 and 46. The noise signal compensated on the basis of the subtraction is sent to both the control sound signal outputting circuit 50 and the delay circuit 54.

Operation and functional effect of the noise control apparatus of the second embodiment are similar to those of the first embodiment and, thus, their description will be omitted.

Referring to Figures 6A and 6B, there is illustrated a noise control apparatus for a vacuum cleaner in accordance with a third embodiment of the present invention.

Figures 6A and 6B, elements corresponding to those in Figures 1 to 4 illustrating the first embodiment of the present invention are denoted by the same reference numerals and, thus, their description will be omitted.

In accordance with this embodiment, the noise detecting unit adapted to detect noise generated from the motor 20 and the impeller 22 and generate a noise level signal on the basis of the detection comprises a first noise detecting unit 62

and a second noise detecting unit 64. The first noise detecting unit 62 is attached to the outer surface of the housing of motor 20 whereas the second noise detecting unit 64 is attached to the bottom surface of cleaner body 32 such that it is spaced apart from both the motor 20 and the impeller 22.

In similar to the noise control apparatus of the first embodiment, the noise control apparatus of the third embodiment includes a control unit 60 which is a microprocessor for controlling the overall operations of the noise control apparatus. As shown in Figure 6B the control unit 60 comprises a control sound signal outputting circuit 70 adapted to receive noise signals from the first and second noise detecting units 62 and 64, derive an average of the receive noise signals, generate a control sound signal having the same amplitude and intensity as those of the average noise signal and the opposite phase to that of the average noise signal. The control sound signal from the control sound outputting circuit 70 is transmitted to a first control sound generating unit 66 and a second control sound generating unit 68, each of which has a construction identical to that of the control sound generating unit 6 of the first embodiment. The control unit 60 further comprises a pair of first compensation circuits respectively denoted by the reference numerals 78 and 80 and a second

compensation circuit denoted by the reference numeral 72. The second compensation circuit 72 serves to generate a compensation signal for minimizing the intensity of the error sound. For generating such a compensation signal, the second compensation circuit 72 performs an operation for the compensation signal, based on the error sound signal generated from the error sound detecting unit 8 and the noise signals respectively detected by the first and second noise detecting unit 62 and 64. The compensation signal from the second compensation circuit 72 is sent to the control sound signal outputting circuit 70. A delay circuit 74 is also provided for delaying the noise signals respectively outputted from the first and second noise detecting unit 62 and 64 for a predetermined time so as to synchronize the noise generated from the noise source with the control sounds generated from the first and second control sound generating unit 66 and 68 at the stage of the error sound detecting unit 8. The delayed noise signal from the delay circuit 74 is sent to the second compensation circuit 72. The control unit 60 further comprises a control sound signal intensity adjusting circuit 76 adapted to receive the control sound signal from the control sound signal outputting circuit 70 and adjust the intensity of the received signal. The first compensation circuits 78 and 80 serve to transmit the noise generated from the noise source to the control signal outputting circuit 70 and the delay

circuit 70 and the delay circuit 74. To this end, the first compensation circuits 78 and 80 subtract the control sound signal generated from the control sound signal outputting circuit 70 and adjusted in intensity by the intensity adjusting circuit 76 from respective noise signals detected by the first and second noise detecting unit 62 and 64. Each noise signal compensated on the basis of the substraction is sent to both the control sound signal outputting circuit 70 and the delay circuit 74.

Operation and function effect of the noise control apparatus of the third embodiment are similar to those of the first embodiment and, thus, their description will be omitted.

Referring to Figures 7A and 7B, there is illustrated a noise control apparatus for a vacuum cleaner in accordance with a fourth embodiment of the present invention.

In Figures 7A and 7B, elements corresponding to those in Figures 1 to 4 illustrating the first embodiment of the present invention are denoted by the same reference numerals and, thus, their description will be omitted.

In accordance with this embodiment, the noise control apparatus includes a noise detecting unit 84 disposed in the

suction pipe 28 and adapted to detect noise generated from the noise source and generate a noise level signal. A control unit 82 which will be described hereinafter receives the noise level signal.

Between the noise detecting unit 84 and the control unit 82, an amplifier 88, a low pass filter 90 and analog/digital converter 92 are connected in series so as to convert the noise detected by the noise detecting unit 84 into an electrical signal. In the suction pipe 28, a control sound generating unit 94 is also disposed which serves to receive a control signal from the control unit 82 and thereby generates a control sound for attenuating the noise generated from the noise source.

The noise control apparatus further includes an error sound detecting unit 96 disposed in the suction pipe 28 and adapted to detect an error sound indicative of the result of the attenuation of the noise from the motor 20 and the impeller 22 by the control sound from the control sound from the control sound generating unit 94. The error sound detecting unit 96 generates an error sound signal on the basis of the detection and sends it to the control unit 82.

Between the control sound generating unit 94 and the control unit 82, a digital/analog converter 98, an amplifier 100 and

a low pass filter 102 are connected in series. The digital/analog converter 98 converts the control signal of the control unit 82 into an analog signal. The amplifier 100 serves to amplify the analog signal from the digital/analog converter 98 to a predetermined level. The low pass filter 102 permits the low frequency component of the amplified analog signal to pass therethrough.

Similarly, an amplifier 104, a low pass filter 106 and an analog/digital converter 108 are connected in series between the error sound detecting unit 96 and the control unit 82. The amplifier 104 serves no amplify the error sound signal generated from the error sound detecting unit 96 to a predetermined level. The low pass filter 106 permits the low frequency component of the amplified error sound signal pass therethrough. The analog/digital converter 108 converts the error sound signal outputted from the low pass filter 106 into a digital signal.

The control unit 82 is a microprocessor for controlling the overall operations of the noise control apparatus. As shown in Figure 7B, the control unit 82 comprises a control sound signal outputting circuit 110 for receiving the noise signal from the noise detecting unit 84 and generating a control sound signal having the same amplitude and intensity as those of the noise signal and the opposite phase to that

of the noise signal. The control sound signal from the control sound signal outputting circuit 110 is transmitted to the control sound generating unit 94. The control unit 82 further comprises a pair of compensation circuits, the first one of which is denoted by the reference numeral 118 and the second one of which is denoted by the reference numeral 112. The second compensation circuit 112 serves to generate a compensation signal for minimizing the intensity of the error sound. For generating such a compensation signal, the second compensation circuit 112 performs an operation for the compensation signal, based on the error sound signal generated from the error sound detecting unit 96 and the noise signal detected by the noise detecting unit 84. The compensation signal from the second compensation circuit 112 is sent to the control sound signal outputting circuit 110. A delay circuit is coupled between the noise detecting unit 84 and the second compensation circuit 112. The delay circuit 114 is adapted to delay the noise signal outputted from the noise detecting unit 84 for a predetermined time so as to synchronize the noise generated from the noise source and control sound generated from the control sound generating unit 94 at the stage of the error sound detecting unit 96. The delayed noise signal from the delay circuit 114 is sent to the second compensation circuit 112. The control unit 82 comprises a control sound signal intensity adjusting circuit

116 adapted to receive the control sound signal from the control sound signal outputting circuit 110 and adjust the intensity of the received signal. The first compensation circuit 118 serves to transmit only the noise generated from the noise source to the control sound signal outputting circuit 110 and the delay circuit 114. To this end, the first compensation circuit 118 subtracts the control sound signal generated from the control sound signal outputting circuit 110 and adjusted in intensity by the intensity adjusting circuit 116 from the noise signal detected by the noise detecting unit 84. The noise signal compensated on the basis of the subtraction is sent to both the control sound signal outputting circuit 110 and the delay circuit 114.

The suction pipe 28 has a trumpet-shaped inlet portion having a cross-section gradually increasing toward the inlet end thereof, as shown in Figure 8. With such a shape of the inlet portion, the suction pipe 28 permits the noise generated from the motor 20 and the impeller 22 to get away therefrom smoothly and the dust sucked from the floor to flow toward the dust collecting chamber 27 smoothly.

The cross-sectional area of the trumpet-shaped inlet portion of the suction pipe 86 can be expressed by the following equation:

S = So * e * m * x

where, "So" represents the cross-sectional area of the neck of the inlet portion, "m" the constant indicative of the divergence of the trumpet shape, "x" the distance from the neck to the inlet end, and "e" the epsilon indicative of natural logarithm.

As shown in Figures 8 and 9, the noise detecting unit 84 and the error sound detecting unit 96 are disposed in sealed boxes 120 and 122, respectively. The boxes 120 and 122 are disposed in a dust sucking path defined in the suction tube 28. In the boxes 120 and 122, sound-absorbing members 124 and 126 are disposed at one sides of the noise detecting unit 84 and the error sound detecting unit 96, respectively. A plurality of fine pores 128 are also provided at portions of the suction pipe 28 respectively being in contact with the sound-absorbing members 124 and 126. Together with the fine pores 128, the sound-absorbing members 124 and 126 serve to absorb noise generated due to dust-carried air being sucked into the suction pipe 28. By the provision of the sound absorbing members 124 and 126 and the fine pores 128, the noise detecting unit 84 and the error sound detecting unit 96 can detect accurately the noise generated from the motor 20 and the impeller 22 and the error sound.

Operation and functional effect of the noise control apparatus of the fourth embodiment are similar to those of the first embodiment and, thus, their description will be omitted.

Having described specific preferred embodiments of the invention with reference to the accompanying drawings, it is to be understood that the invention is not limited to those precise embodiments, and that various changes and modifications may be effected therein by one skilled in the art without departing from the scope or spirit of the invention as defined in the appended claims.

As apparent from the above description, the present invention provides a noise control apparatus for a vacuum cleaner, capable of effectively attenuating noise with a simple construction including a noise detecting unit, an error sound detecting unit and a control sound generating unit all being disclosed in a cleaner body or a suction pipe.

Since the noise control apparatus of the present invention has the simple construction, it can be installed in any vacuum cleaner conveniently and simply.

In accordance with the present invention, a low pass filter

may be coupled to each of the noise detecting unit, the error sound detecting unit and the control sound generating unit. By virtue of the provision of such a low pass filter, it is possible to greatly attenuate noise of 500Hz or below.

CLAIMS

1. A noise control apparatus for a vacuum cleaner comprising:
control means;
noise detecting means for detecting a noise generated by a noise source, generating a noise level signal on the basis of the noise detection, and sending the noise level signal to the control means;
control sound generating means for generating a control sound adapted to attenuate the noise from the noise source under the control of the control means; and
error sound detecting means for detecting an error sound indicative of the result of the noise attenuation by the control sound from thecontrol soundgenerating means, generating an error sound signal on the basis of the error sound detection, and sending the error sound signal to the control means.

2. A noise control apparatus in accordance with claim 1, wherein the noise source comprises a dust-sucking motor mounted equipped in the vacuum cleaner and an impeller driven by the dust-sucking motor.

3. A noise control apparatus in accordance with claim 1, wherein the noise detecting means is attached to a housing

of a dust-sucking motor mounted in the vacuum cleaner so as to detect a noise generated from the dust-sucking motor.

4. A noise control apparatus in accordance with claim 1, wherein the noise detecting means is disposed in the vicinity of a dust-sucking motor mounted in the vacuum cleaner so as to detect a noise generated from the dust-sucking motor.

5. A noise control apparatus in accordance with claim 1, wherein the noise detecting means is disposed in a suction pipe mounted in the vacuum cleaner so as to detect a noise generated from a dust-sucking motor mounted in the vacuum cleaner.

6. A noise control apparatus in accordance with claim 1, wherein the control means comprises:

a control sound signal outputting circuit adapted to receive the noise level signal from the noise detecting means, generate a control sound signal having the same amplitude and intensity as those of the noise level signal and the opposite phase to that of the noise level signal, and send the control sound signal to the control sound generating means;

a second compensation circuit adapted to operate a compensation signal for minimizing intensity of an

error sound, based on the error sound signal from the error sound detecting means and the noise level signal from the noise detecting means, and send the compensation signal to the control sound signal outputting circuit;

a delay circuit adapted to delay the noise level signal outputted from the noise detecting means for a predetermined time such that the noise generated from the noise source is synchronized with the control sound generated from the control sound generating means at the stage of the error sound detecting means, and send the delayed noise level signal to the second compensation circuit;

a control sound signal intensity adjusting circuit adapted to receive the control sound signal from the control sound signal outputting circuit, and adjust intensity of the received control sound signal; and

a first compensation circuit adapted to subtract the control sound signal generated from the control sound signal outputting circuit and adjusted in intensity by the intensity adjusting circuit from the noise level signal generated from the noise detecting means and send the noise level signal compensated on the basis of the subtraction to both the control sound signal outputting circuit and the delay circuit, whereby only the noise generated from the noise source is transmitted to the control sound signal outputting circuit and the delay circuit.

7. A noise control apparatus in accordance with claim 1, wherein the control sound generating means comprises a speaker disposed in the vicinity of an air filter mounted in the vacuum cleaner and adapted to attenuate the noise generated from the noise source so as to prevent the noise from being transmitted outwardly from the vacuum cleaner.

8. A noise control apparatus in accordance with claim wherein the control sound generating means comprises a speaker disposed in a suction pipe equipped in the vacuum cleaner and adapted to attenuate the noise generated from the noise source so as to prevent the noise from being transmitted outwardly from the suction pipe.

9. A noise control apparatus for a vacuum cleaner comprising:

control means;

noise detecting means disposed in a suction pipe equipped in the vacuum cleaner and adapted to detect a noise generated from a noise source, generate a noise level signal on the basis of the noise detection and send the noise level signal to the control means;

control sound generating means disposed in the suction pipe and adapted to generate a control sound for attenuating the noise from the noise source under a control of the control means; and

error sound detecting means disposed in the suction pipe and adapted to detect an error sound indicative of the result of the noise attenuation by the control sound from the control sound generating means, generate an error sound signal on the basis of the error sound detection and send the error sound signal to the control means.

10. A noise control apparatus in accordance with claim 9, wherein the noise detecting means is connected to the control means via an amplifier, a low pass filter and an analog/digital converter, whereby the noise detected by the noise detecting means is converted into an electrical signal.

11. A noise controlapparatus in accordance with claim 9, wherein the control sound generating means is connected to the control means via a digital/analog converter for converting the control signal of the control means into an analog signal, an amplifier for amplifying the analog signal from the digital/analog converter to a predetermined level and a low pass filter for permitting a low frequency component of the amplified analog signal to pass therethrough.

12. A noise control apparatus in accordance with claim 9, wherein the error sound detecting means is connected to the

control means via an amplifier for amplifying the error sound signal generated from the error sound detecting means to a predetermined level, a low pass filter for permitting a low frequency component of the amplified error sound signal to pass therethrough and an analog/digital converter for converting the error sound signal outputted from the low pass filter into a digital signal.

13. A noise control apparatus in accordance with claim 9, wherein the control means comprises:

a control sound signal outputting circuit adapted to receive the noise level signal from the noise detecting means, to generate a control sound signal having the same amplitude and intensity as those of the noise level signal and the opposite phase to that of the noise level signal, and send the control sound signal to the control sound generating means;

a second compensation circuit adapted to operate a compensation signal for minimizing intensity of an error sound, based on the error sound signal from the error sound detecting means and the noise level signal from the noise detecting means, and send the compensation signal to the control sound signal outputting circuit;

a delay circuit adapted to delay the noise level signal outputted from the noise detecting means for a predetermined time such that the noise generated from the noise source is

synchronized with the control sound generated from the control sound generating means at the stage of the error sound detecting means, and send the delayed noise level signal to the second compensation circuit;

a control sound signal intensity adjusting circuit adapted to receive the control sound signal from the control sound signal outputting circuit, and adjust intensity of the received control sound signal; and

a first compensation circuit adapted to subtract the control sound signal generated from the control sound signal outputting circuit and adjusted in intensity by the intensity adjusting circuit from the noise level signal generated from the noise detecting means and send the noise level signal compensated on the basis of the subtraction to both the control sound signal outputting circuit and the delay circuit, whereby only the noise generated from the noise source is transmitted to the control sound signal outputting circuit and the delay circuit.

14. A noise control apparatus in accordance with claim 9, wherein the suction pipe has a trumpet-shaped inlet portion having a cross-section gradually increasing toward an outer end thereof such that it permits the noise generated from the noise source to get away therefrom smoothly and dust sucked from a floor being cleaned to flow toward a dust

collecting chamber defined in the vacuum cleaner smoothly.

15. A noise control apparatus in accordance with claim 9, wherein the noise detecting means and the error sound detecting means are disposed in sealed boxes disposed in a dust sucking path defined in the suction tube, respectively, a pair of sound-absorbing members are disposed in the sealed boxes, atone sides of the noise detecting means and the error sound detecting means, respectively, and a plurality of fine pores are provided at portions of the suction pipe respectively being in contact with the sound-absorbing members, the sound-absorbing members together with the fine pores serving to absorb noise generated due to dust-carried air being sucked into the suction pipe, thereby enabling the noise detecting means and the error sound detecting means to detect accurately the noise generated from the noise source and the error sound, respectively.

Patents Act 1977
Examiner's report to the Comptroller under Section 17
(The Search report)

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Relevant Technical Fields (i) UK Cl (Ed.M) G3R (RBS, RBU); H4J (JGA) (ii) Int Cl (Ed.5) G10K 11/16; G05D 19/02 **Databases** (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE DATABASES: WPI	Application number GB 9410084.9 Search Examiner ANDREW BARTLETT Date of completion of Search 27 JULY 1994 Documents considered relevant following a search in respect of Claims :- 1-15

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